Plant Archives Vol. 26, Supplement 1, 2026 pp. 117-125 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-1.017

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH ANALYSIS AND YIELD OF MAIZE (*ZEA MAYS* L.) IN VERTISOLS OF NORTHERN TRANSITION ZONE OF KARNATAKA INDIA

Vinaykumar B.B.[1], Patil S.L.[2*], Patil C.R.[3] and Shivakumar B.G.[4]

[1]Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Dharwad - 580 005, Karnataka, India

[2]ICAR-IIPR, Regional Research Station, Dharwad-580 005, Karnataka, India

[3]Department of Agricultural Microbiology, College of Agriculture, University of Agricultural Sciences, Dharwad - 580 005, Karnataka, India

[4]ICAR-IGFRI, SRRS, Dharwad-580 005, Karnataka, India

*Corresponding author E-mail: slpatil1001@gmail.com

(Date of Receiving : 09-08-2025; Date of Acceptance : 20-10-2025)

ABSTRACT

A field experiment was conducted during *kharif* season of 2024 at ICAR-IIPR, Regional Research Station, Dharwad, Karnataka to study the effect of integrated nutrient management on growth analysis and yield of maize (*Zea mays* L.). The experiment was replicated thrice in a Randomized Complete Block Design with eight treatments using the maize variety *i.e.* DKC 9133. Results indicated that significantly higher maize grain yield of 8006 kg ha^{-1}, stover yield of 7044 kg ha^{-1}, AGR (0.75, 2.67 and 4.44 g day^{-1} plant^{-1} during 0-30, 30-60, 60-90 DAS, respectively), CGR (6.26, 22.26 and 37.04 g m^{-2} day^{-1}, respectively), RGR (0.104 and 0.003 g g^{-1} day^{-1} plant^{-1} during 0-30 and 90-harvest period, respectively), NAR (4.72 and 4.88 g m^{-2} day^{-1} during 30-60 and 60-90 DAS, respectively), LAD (155.5, 227.6 and 214.1 days during 30-60, 60-90 DAS and 90 DAS-harvest, respectively), SLW (3.78 mg cm^{2} during 60 DAS), significantly lower SLA (264.3 cm^{2} g^{-1} during 60 DAS), LAR (91.0 and 37.6 cm^{2} g^{-1} during 60 and 90 DAS, respectively) and LWR (0.556 during 30 DAS) were recorded with application of RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}.

Keywords **:** Growth analysis, Integrated nutrient management (INM), *Kharif* season, Maize, and Physiological indices

Introduction

Maize (*Zea mays* L.) is one of the most widely cultivated cereal grains and ranks first among the world's leading crops. Domesticated in Central America and it is known as the "queen of cereals" because of its higher production potential compared to other cereals. Being a nutrient-exhaustive crop, maize needs greater quantity of nutrients and its productivity is closely associated with efficient nutrient management system (Tyagi *et al.*, 1998). Currently, maize is cultivated on an area of 206.3 million hectares (Mha) in the world, with a total production of 1,210.2 million tonnes (Mt) and an average productivity of 5.87 t ha^{-1}. In India, maize is cultivated over an area of 10.74 Mha, yielding 38.09 Mt with a productivity of 3.54 t ha^{-1} (*Anon.*, 2024). Seeds are composed of carbohydrates (70%), gluten-free protein (11.1%), fat (3.6%), fiber (2.7%), essential minerals and vitamins (1.5%). Due to its high economic value, maize is often referred to as "yellow gold". In recent years, the area of maize in northern transitional zone of Dharwad during *kharif* season has increased due to higher rainfall and its uniform distribution. However, due to continuous use of inorganic fertilizers with lower organic amendments, the productivity evinces a declining trend. Therefore, it is essential to stabilize and increase productivity through INM including low cost biofertilizers. A sustainable production of maize can be achieved by applying an appropriate combination of chemical fertilizers and green or organic manures/amendments including microbial cultures along with micronutrients (Chandrashekar *et al*., 2000). Growth analysis provides critical insights into plant responses to nutrient regimes by quantifying physiological parameters such as absolute growth rate (AGR), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), and leaf-based indices like specific leaf area (SLA), specific leaf weight (SLW), and leaf area duration (LAD). These metrics indicate the decipher the dynamics of dry matter partitioning and resource utilization with integrated nutrient management practices.

Material and Methods

A field experiment was conducted at ICAR-IIPR, Regional Research Station, Dharwad during rainy (*kharif*) season of 2024. The soil of the experimental site was Vertisol (medium deep black). The experiment was replicated thrice in a Randomized Complete Block Design with eight treatments using the maize variety *i.e.* DKC 9133. Treatments comprised of T_1: FP -75% RRF + FYM at 1.0 t ha^{-1}, T_2: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 1.0 t ha^{-1}, T_3: FP + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}, T_4: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}, T_5: RRF + FYM at 2.0 t ha^{-1}, T_6: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 2.0 t ha^{-1}, T_7: RRF + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1} and T_8: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1} . The total annual rainfall for the experimental period was 714.4 mm. Excess rainfall during the experimental period especially flowering to grain formation resulted in waterlogging, nutrient leaching, and an increased incidence of insect pests and diseases and reduced marginally crop yields. The data collected from the experiment at different growth stages and at harvest was subjected to statistical analysis as described by Gomez and Gomez (1984). Details of the formulae's used in the growth analysis are presented in this chapter below.

Growth analysis

Absolute growth rate (Richards, 1969)

$$\text{AGR (Dry weight)} = \frac{W_2 - W_1\ (\text{g day}^{-1}\ \text{plant}^{-1})}{t_2 - t_1}$$

Where, W_2, W_1 refers to the dry matter accumulation per plant at time t_2 and t_1 (days) respectively.

Crop growth rate (Watson, 1952)

$$\text{CGR (g m}^{-2}\text{ day}^{-1}) = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{P}$$

Where, W_2 and W_1, dry weights of plant at the t_2 and t_1 time intervals respectively, and P is the area $plant^{-1}$ in (m^{-2}).

Relative growth rate (Fisher, 1921)

$$\text{RGR (g g}^{-1}\text{ day}^{-1}\text{ plant}^{-1}) = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1}$$

Where,

W_1 = Weight of dry matter (g) at time t_1

W_2 = Weight of dry matter (g) at time t_2

$t_2 - t_1$ = the interval in days

Loge = natural logarithms (logarithms to base of e of 2.3026)

Relative growth rate is expressed in g g^{-1} $plant^{-1}$ day^{-1}

Leaf area duration (Watson, 1956)

$$\text{LAD (days)} = \frac{L_1 + L_2}{2} \times (t_2 - t_1)$$

Where, L_1 and L_2 are the LAI at two sampling times t_1 and t_2, respectively.

Net assimilation rate (Gregory, 1926).

$$\text{NAR (g m}^{-2}\text{ day}^{-1}) = \frac{(W_2 - W_1)\ (\text{Log}_e LA_2 - \text{Log}_e LA_1)}{(t_2 - t_1)\ (LA_2 - LA_1)}$$

Where, W_1 and W_2 are the dry weights; LA_1 and LA_2 are leaf area at two sampling times t_1 and t_2, respectively and Log_e is natural logarithm

Specific leaf area (cm^2 g^{-1})

$$\text{SLA} = \frac{\text{Leaf area (cm}^2)}{\text{Leaf dry weight (g)}}$$

Specific leaf weight (mg cm^{-2})

$$\text{SLW} = \frac{\text{Leaf dry weight (g)}}{\text{Leaf area (cm}^2)}$$

Leaf area ratio (cm^2 g^{-1})

$$\text{LAR} = \frac{\text{Leaf area (cm}^2)}{\text{Total plant dry weight (g)}}$$

Leaf weight ratio (g g^{-1})

$$\text{LWR} = \frac{\text{Leaf dry weight (g)}}{\text{Total plant dry weight (g)}}$$

Results and Discussions

Application of RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1} (T_8) recorded significantly higher maize grain yield by 36 per cent (8006 kg ha^{-1}) and straw yield by 21 per cent (7044 kg ha^{-1}) over FP -75% RRF + FYM at 1.0 t ha^{-1} (5882 kg ha^{-1} and 5832 kg ha^{-1}, grain and straw yield, respectively) (Table 1). The higher maize grain and straw yield is attributed to greater dry matter accumulation in leaf, stem and cobs at harvest in T_8 treatment compared to T_1 treatment (Kamalakumari and Singaram, 1996, Verma, 2001 and Ashok Kumar *et al.,* 2005). The increase in yield is a result of higher quantity of available macro and micro nutrients in the soil in T_8 treatment compared to T_1 treatment. Sharma and Kumar (2014) and Singh *et al*. (2025) who opined that integrated nutrient management enhances maize yields and water use efficiency by improving root development and physiological efficiency.

Among integrated nutrient management practices, RRF + *rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1} (T_8) resulted in significantly greater values among growth indices over the farmer's practice *i.e.* 75% RRF + FYM 1.0 t ha^{-1}. During 0-30, 30-60, and 60-90 DAS, T_8 produced higher absolute growth rates (AGR) of 0.75, 2.67, and 4.44 g day^{-1} $plant^{-1}$ (Table 2) and crop growth rates (CGR) of 6.26, 22.26, and 37.04 g m^{-2} day^{-1} (Table 3), reflecting robust vegetative expansion with balanced macronutrient supply, organic amendments, and microbial synergy (Aguilar-Paredes *et al*., 2020). The relative growth rate (RGR) values were higher in T_8 treatment *i.e.* 0.104 g g^{-1} day^{-1} during 0-30 DAS and 0.003 g g^{-1} day^{-1} from 90 DAS to harvest, indicating efficient early biomass accumulation and sustained growth relative to total plant mass, whereas mid-season RGR converged across treatments as plants shifted towards reproductive development (Taiz and Zeiger, 2010, Gusain *et al*., 2015) (Table 4). The net assimilation rate (NAR) increased to 4.72 and 4.88 g m^{-2} day^{-1} during 30-60 and 60-90 DAS in T_8 treatment and is attributed to enhanced chlorophyll content, leaf area and nutrient-driven photosynthetic efficiency facilitated by PGPR and micronutrient availability before declining during post-90 DAS when assimilates diverted to grain filling (Sharma and Mittra, 1991, Santoyo *et al*., 2021) (Table 5). The leaf area duration (LAD) in T_8 treatment was significantly higher by 18.4, 18.7 and 15.2 per cent during 30-60, 60-90 and 90-harvest periods, respectively over T_1 treatment, ensuring prolonged photosynthetic capacity during critical stages of maize growth (Cakmak, 2008 and Batool *et al*., 2021) (Table 6).

The physiological responses to nutrient management were evident in the contrasting strategies of leaf biomass allocation, as revealed by specific leaf area (SLA) and specific leaf weight (SLW). The nutrient-limited farmer's practice (T_1) recorded higher SLA, particularly in the later growth stages *i.e.* 261.8 cm^2 g^{-1} at 90 DAS (Table 7). This indicates the formation of thinner leaves, a compensatory strategy to maximize light interception when photosynthetic capacity per unit mass is low.

Integrated nutrient management treatment (T_8) consistently produced leaves with a higher SLW *i.e.* 3.78 mg cm^{-2} at 60 DAS and a correspondingly lower SLA (Table 8). A high SLW signifies thicker, denser leaves with a greater investment in photosynthetic rate per unit area, a feature made possible by the balanced and readily available nutrient supply. This strategic allocation of biomass to create more photosynthetically potent leaves, rather than simply expanding leaf area, is a definitive physiological marker of a non-resource-limited plant and provides a clear explanation for the superior net assimilation and growth rates observed in the T_8 treatment.

Significant reductions in LAR at later stages in RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1} indicate a physiological shift from vegetative to reproductive growth. The initial high LAR values reflect investment in photosynthetic surface, which later stabilizes with biomass accumulation.

At 30 DAS, higher LWR of 0.605 recorded in Farmer's Practice - 75% RRF + FYM at 1.0 t ha^{-1} (T_1), while a lower LWR of 0.556 was observed in RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1} (Table 10). Higher LWR in T_1 treatment at the early stages may be attributed to the greater proportion of biomass allocation to leaf tissue relative to stem and root. It is also due to sub-optimal nutrient availability limiting overall growth and favouring leaf development to enhance early photosynthetic capacity. In contrast, a lower LWR in T_8 treatment may be attributed to a more balanced and vigorous overall plant growth triggered by the combined application of RRF, microbial consortia and micronutrients (Zn and Fe), which promoted uniform biomass allocation across all plant parts, including stem and roots, thereby reducing the relative proportion of biomass in the leaves. The microbial consortia likely facilitated improved nutrient mineralization and uptake, particularly nitrogen and micronutrients, which are critical for overall plant growth and development. Additionally, the increased Fe and Zn supply may have stimulated chloroplast development and enzymatic function, and thus further enhance the photosynthetic efficiency and reduce the need for excessive leaf biomass (Cakmak, 2008 and Marschner, 2012).

Conclusion

Among the integrated nutrient management practices, RRF + *rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} seeds + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1} (T_8) resulted in significantly higher maize grain, straw yield and growth indices over the farmer's practice *i.e.* 75% RRF + FYM 1.0 t ha^{-1}. The physiological basis for this advantage lies in a more efficient resource allocation strategy. The T_8 treatment fostered the development of thicker, denser, and more photosynthetically potent leaves, as evidenced by a consistently high specific leaf weight (SLW) and low specific leaf area (SLA). In contrast, the nutrient-limited T_1 treatment induced a compensatory response of creating thinner leaves and allocating a disproportionately high biomass to foliage early on, indicated by a high leaf weight ratio (LWR). Adoption of integrated nutrient management practices in Vertisols of the northern transitional zone of Karnataka will improve and sustain crop productivity, improve resource-use efficiency and contribute to climate resilient agriculture

Table 1 : Grain yield and stover yield maize as influenced by integrated nutrient management

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
FP -75% RRF + FYM at 1.0 t ha^{-1}	5882^{d}	5832^{b}
FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 1.0 t ha^{-1}	6271^{cd}	6094^{b}
FP + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	6519^{cd}	6455^{ab}
FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	7073^{a-c}	6448^{ab}
RRF + FYM at 2.0 t ha^{-1}	6980^{bc}	6548^{ab}
RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 2.0 t ha^{-1}	7780^{ab}	6944^{a}
RRF + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	7836^{ab}	6936^{a}
RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	8006^{a}	7044^{a}
S.Em. ±	297	219
LSD at 5%	900	664

FP - Farmers practice -75% RRF, FYM – Farmyard manure
RRF- Recommended rate of fertilizer (100:50:50 N:P K kg ha^{-1}) for maize
Means followed by the same letter (s) within a column are not significantly differed by DMRT (P=0.05)

Table 2 : Absolute growth rate (g day^{-1} plant^{-1}) of maize at different growth periods as influenced by integrated nutrient management

Treatments		AGR (g day^{-1} plant^{-1})			
		0-30 DAS	30-60 DAS	60-90 DAS	90 DAS-Harvest
T_1:	FP -75% RRF + FYM at 1.0 t ha^{-1}	0.59^{e}	2.15^{d}	3.39^{d}	1.08^{a}
T_2:	FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 1.0 t ha^{-1}	0.62^{de}	2.19^{d}	3.75^{cd}	0.88^{a}
T_3:	FP + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	0.64^{c-e}	2.22^{d}	3.93^{bc}	0.82^{a}
T_4:	FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	0.65^{c-e}	2.29^{cd}	4.12^{ab}	0.66^{a}
T_5:	RRF + FYM at 2.0 t ha^{-1}	0.67^{b-d}	2.42^{bc}	4.15^{ab}	0.63^{a}
T_6:	RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 2.0 t ha^{-1}	0.70^{a-c}	2.46^{bc}	4.29^{ab}	0.55^{a}
T_7:	RRF + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	0.72^{ab}	2.52^{ab}	4.33^{a}	0.62^{a}
T_8:	RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	0.75^{a}	2.67^{a}	4.44^{a}	0.73^{a}
S.Em. ±		0.02	0.06	0.12	0.20
LSD at 5%		0.06	0.17	0.36	NS

FP - Farmers practice -75% RRF, FYM – Farmyard manure
RRF- Recommended rate of fertilizer (100:50:50 N:P K kg ha^{-1}) for maize
Means followed by the same letter (s) within a column are not significantly differed by DMRT (P=0.05)

Table 3 : Crop growth rate (g m^{-2} day^{-1}) of maize at different growth periods as influenced by integrated nutrient management

Treatments	CGR (g m^{-2} day^{-1} $plant^{-1}$)			
	0-30 DAS	30-60 DAS	60-90 DAS	90 DAS-Harvest
T_1: FP -75% RRF + FYM at 1.0 t ha^{-1}	4.93^{e}	17.94^{d}	28.24^{d}	8.98^{a}
T_2: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 1.0 t ha^{-1}	5.19^{de}	18.24^{d}	31.24^{cd}	7.37^{a}
T_3: FP + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	5.33^{c-e}	18.46^{d}	32.78^{bc}	6.85^{a}
T_4: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	5.39^{c-e}	19.06^{cd}	34.33^{a-c}	5.48^{a}
T_5: RRF + FYM at 2.0 t ha^{-1}	5.56^{b-d}	20.19^{bc}	34.6^{ab}	5.23^{a}
T_6: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 2.0 t ha^{-1}	5.80^{a-c}	20.5^{bc}	35.74^{ab}	4.62^{a}
T_7: RRF + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	6.00^{ab}	21.04^{ab}	36.11^{a}	5.19^{a}
T_8: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	6.26^{a}	22.26^{a}	37.04^{a}	6.11^{a}
S.Em. ±	0.16	0.47	1.00	1.67
LSD at 5%	0.49	1.42	3.03	NS

FP - Farmers practice -75% RRF, FYM – Farmyard manure
RRF- Recommended rate of fertilizer (100:50:50 N:P:K kg ha^{-1}) for maize
Means followed by the same letter (s) within a column are not significantly differed by DMRT (P=0.05)

Table 4 : Relative growth rate (g g^{-1} day^{-1} $plant^{-1}$) of maize at different growth periods as influenced by integrated nutrient management

Treatments	RGR (g g^{-1} day^{-1} $plant^{-1}$)			
	0-30 DAS	30-60 DAS	60-90 DAS	90 DAS-Harvest
T_1: FP -75% RRF + FYM at 1.0 t ha^{-1}	0.096^{d}	0.051^{a}	0.027^{a}	0.005^{a}
T_2: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 1.0 t ha^{-1}	0.098^{cd}	0.050^{a}	0.028^{a}	0.004^{ab}
T_3: FP + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	0.098^{cd}	0.050^{a}	0.029^{a}	0.004^{ab}
T_4: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	0.099^{b-d}	0.050^{a}	0.029^{a}	0.003^{ab}
T_5: RRF + FYM at 2.0 t ha^{-1}	0.100^{bc}	0.051^{a}	0.028^{a}	0.003^{ab}
T_6: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 2.0 t ha^{-1}	0.101^{a-c}	0.050^{a}	0.029^{a}	0.002^{b}
T_7: RRF + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	0.102^{ab}	0.050^{a}	0.028^{a}	0.003^{ab}
T_8: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	0.104^{a}	0.051^{a}	0.028^{a}	0.003^{ab}
S.Em. ±	0.0010	0.0013	0.0007	0.0008
LSD at 5%	0.0031	NS	NS	0.0026

FP - Farmers practice -75% RRF, FYM – Farmyard manure
RRF- Recommended rate of fertilizer (100:50:50 N:P:K kg ha^{-1}) for maize
Means followed by the same letter (s) within a column are not significantly differed by DMRT (P=0.05)

Table 5 : Net assimilation rate (g m^{-2} day^{-1} $plant^{-1}$) of maize at different growth periods as influenced by integrated nutrient management

Treatments	NAR (g m^{-2} day^{-1} $plant^{-1}$)		
	30-60 DAS	60-90 DAS	90 DAS-Harvest
T_1: FP -75% RRF + FYM at 1.0 t ha^{-1}	4.430^{ab}	4.420^{b}	1.450^{a}
T_2: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 1.0 t ha^{-1}	4.310^{ab}	4.740^{ab}	1.170^{a}
T_3: FP + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	4.190^{b}	4.750^{ab}	1.070^{a}
T_4: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	4.250^{ab}	4.800^{ab}	0.840^{a}
T_5: RRF + FYM at 2.0 t ha^{-1}	4.420^{ab}	4.720^{ab}	0.780^{a}
T_6: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 2.0 t ha^{-1}	4.440^{ab}	4.830^{ab}	0.680^{a}
T_7: RRF + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	4.500^{ab}	4.820^{ab}	0.750^{a}
T_8: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	4.720^{a}	4.880^{a}	0.860^{a}
S.Em. ±	0.147	0.125	0.250
LSD at 5%	0.446	0.379	NS

FP - Farmers practice -75% RRF, FYM – Farmyard manure
RRF- Recommended rate of fertilizer (100:50:50 N:P:K kg ha^{-1}) for maize
Means followed by the same letter (s) within a column are not significantly differed by DMRT (P=0.05)

Table 6 : Leaf area duration (days) at different growth stages of maize as influenced by integrated nutrient management

Treatments	Leaf area duration			
	0-30 DAS	30-60 DAS	60-90 DAS	90 DAS-Harvest
T_1: FP -75% RRF + FYM at 1.0 t ha^{-1}	35.6^{a}	131.3^{d}	191.7^{g}	185.9^{e}
T_2: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 1.0 t ha^{-1}	36.5^{a}	137.9^{d}	198.0^{f}	187.8^{e}
T_3: FP + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	37.6^{a}	144.2^{c}	206.9^{e}	191.6^{de}
T_4: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	37.7^{a}	147.0^{bc}	214.6^{d}	196.7^{c-e}
T_5: RRF + FYM at 2.0 t ha^{-1}	38.3^{a}	151.8^{ab}	219.8^{c}	201.5^{b-d}
T_6: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 2.0 t ha^{-1}	38.4^{a}	152.0^{ab}	221.8^{bc}	207.3^{a-c}
T_7: RRF + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	38.4^{a}	154.3^{a}	224.7^{ab}	209.3^{ab}
T_8: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	38.8^{a}	155.5^{a}	227.6^{a}	214.1^{a}
S.Em. ±	1.7	1.9	1.5	3.6
LSD at 5%	NS	5.9	4.6	10.8

FP - Farmers practice -75% RRF, FYM – Farmyard manure
RRF- Recommended rate of fertilizer (100:50:50 N:P:K kg ha^{-1}) for maize
Means followed by the same letter (s) within a column are not significantly differed by DMRT (P=0.05)

Table 7 : Specific leaf area (cm^2 g^{-1}) at different growth stages of maize as influenced by integrated nutrient management

Treatments	Specific leaf area			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**
T_1: FP -75% RRF + FYM at 1.0 t ha^{-1}	265.2^{a}	267.2^{ab}	261.8^{a}	234.7^{a}
T_2: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 1.0 t ha^{-1}	265.8^{a}	273.3^{ab}	248.3^{a}	227.8^{a}
T_3: FP + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	263.5^{a}	281.1^{ab}	245.7^{a}	221.3^{a}
T_4: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	261.2^{a}	282.0^{ab}	259.4^{a}	215.0^{a}
T_5: RRF + FYM at 2.0 t ha^{-1}	255.5^{a}	286.7^{a}	257.8^{a}	223.4^{a}
T_6: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 2.0 t ha^{-1}	257.2^{a}	281.1^{ab}	252.1^{a}	231.2^{a}
T_7: RRF + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	254.9^{a}	280.9^{ab}	251.2^{a}	227.3^{a}
T_8: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	247.4^{a}	264.3^{b}	242.0^{a}	223.1^{a}
S.Em. ±	11.8	5.9	10.8	6.2
LSD at 5%	NS	17.9	NS	NS

FP - Farmers practice -75% RRF, FYM – Farmyard manure
RRF- Recommended rate of fertilizer (100:50:50 N:P:K kg ha^{-1}) for maize
Means followed by the same letter (s) within a column are not significantly differed by DMRT (P=0.05)

Table 8 : Specific leaf weight (mg cm^2) at different growth stages of maize as influenced by integrated nutrient management

Treatments	Specific leaf weight			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**
T_1: FP -75% RRF + FYM at 1.0 t ha^{-1}	3.77^{a}	3.74^{ab}	3.82^{a}	4.26^{a}
T_2: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 1.0 t ha^{-1}	3.76^{a}	3.66^{ab}	4.03^{a}	4.39^{a}
T_3: FP + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	3.79^{a}	3.56^{ab}	4.07^{a}	4.52^{a}
T_4: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	3.83^{a}	3.55^{ab}	3.85^{a}	4.65^{a}
T_5: RRF + FYM at 2.0 t ha^{-1}	3.91^{a}	3.49^{b}	3.88^{a}	4.48^{a}
T_6: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 2.0 t ha^{-1}	3.89^{a}	3.56^{ab}	3.97^{a}	4.33^{a}
T_7: RRF + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	3.92^{a}	3.56^{ab}	3.98^{a}	4.4^{a}
T_8: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	4.04^{a}	3.78^{a}	4.13^{a}	4.48^{a}
S.Em. ±	0.18	0.08	0.17	0.12
LSD at 5%	NS	0.23	NS	NS

FP - Farmers practice -75% RRF, FYM – Farmyard manure
RRF- Recommended rate of fertilizer (100:50:50 N:P:K kg ha^{-1}) for maize
Means followed by the same letter (s) within a column are not significantly differed by DMRT (P=0.05)

Table 9 : Leaf area ratio (cm^2 g^{-1}) at different growth stages of maize as influenced by integrated nutrient management

Treatments	Leaf area ratio			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**
T_1: FP -75% RRF + FYM at 1.0 t ha^{-1}	160.5^{a}	93.0^{ab}	41.7^{a}	33.3^{a}
T_2: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 1.0 t ha^{-1}	156.6^{a}	96.1^{ab}	39.3^{b}	32.7^{a}
T_3: FP + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	156.5^{a}	99.6^{a}	39.4^{b}	32.0^{a}
T_4: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	155.3^{a}	99.3^{a}	39.8^{ab}	31.6^{a}
T_5: RRF + FYM at 2.0 t ha^{-1}	150.8^{a}	98.0^{a}	39.2^{b}	32.2^{a}
T_6: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 2.0 t ha^{-1}	147.1^{a}	96.0^{ab}	38.8^{b}	33.1^{a}
T_7: RRF + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	142.4^{a}	95.2^{ab}	38.3^{b}	32.7^{a}
T_8: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	137.6^{a}	91.0^{b}	37.6^{b}	32.0^{a}
S.Em. ±	7.03	1.9	0.7	1.0
LSD at 5%	NS	5.9	2.0	NS

FP - Farmers practice -75% RRF, FYM – Farmyard manure
RRF- Recommended rate of fertilizer (100:50:50 N:P:K kg ha^{-1}) for maize
Means followed by the same letter (s) within a column are not significantly differed by DMRT (P=0.05)

Table 10 : Leaf weight ratio at different growth stages of maize as influenced by integrated nutrient management

Treatments	Leaf weight ratio			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**
T_1: FP -75% RRF + FYM at 1.0 t ha^{-1}	0.605^{a}	0.348^{a}	0.159^{a}	0.142^{a}
T_2: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 1.0 t ha^{-1}	0.589^{ab}	0.352^{a}	0.158^{a}	0.143^{a}
T_3: FP + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	0.594^{ab}	0.354^{a}	0.160^{a}	0.145^{a}
T_4: FP + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 1.0 t ha^{-1}	0.595^{ab}	0.352^{a}	0.153^{a}	0.147^{a}
T_5: RRF + FYM at 2.0 t ha^{-1}	0.59^{ab}	0.342^{a}	0.152^{a}	0.144^{a}
T_6: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + FYM at 2.0 t ha^{-1}	0.572^{ab}	0.342^{a}	0.154^{a}	0.143^{a}
T_7: RRF + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	0.559^{b}	0.339^{a}	0.152^{a}	0.144^{a}
T_8: RRF + *Rhizosphere* microbial consortia seed treatment at 8 ml kg^{-1} of seed + $ZnSO_4$ and $FeSO_4$ at 25 kg ha^{-1} + FYM at 2.0 t ha^{-1}	0.556^{b}	0.344^{a}	0.155^{a}	0.143^{a}
S.Em. ±	0.012	0.008	0.005	0.003
LSD at 5%	0.036	NS	NS	NS

FP - Farmers practice -75% RRF, FYM – Farmyard manure
RRF- Recommended rate of fertilizer (100:50:50 N:P:K kg ha^{-1}) for maize
Means followed by the same letter (s) within a column are not significantly differed by DMRT (P=0.05)

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